



# Status of Embedded Linux

June 2024

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# Nature of this talk...

- Periodically take a look at the status of embedded Linux
  - Not comprehensive – just a few things I saw
- No way to cover everything
  - Sorry if I missed something you're interested in

# Outline

Linux Kernel  
Technology Areas  
Industry News  
Community  
Conclusions

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Linux Kernel  
Technology Areas  
Industry News  
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# Kernel Versions

- Linux v6.5 – 27 Aug 2023 – 63 days
- Linux v6.6 – 29 Oct 2023 – 63 days
- Linux v6.7 – 7 Jan 2024 – 70 days
- Linux v6.8 – 10 Mar 2024 – 63 days
- Linux v6.9 – 12 May 2024 – 63 days
- Linux v6.10-rc5
  - Expect v6.10 on July 7 or 14)



# Linux v6.5 (Aug 2023)

- Parallelize bringing up CPUs, reducing time to get all processors online
  - But only on X86, for now
- There was a big reorganization of 32-bit devicetree file directory structure
  - To match arm64, mips and riscv
  - See commit 6c1561fb
- Miscellaneous ftrace and perf updates
  - See <https://lwn.net/Articles/937006/>

# Linux v6.6 (Oct 2023)

- Can now build a kernel without buffer-head support
  - Some buffer head functionality can be replaced by iomaps (and folios)
  - Part of an effort to eliminate the buffer head subsystem
    - See <https://lwn.net/Articles/931809/>
    - This might lead to older filesystems (that depend on the buffer cache) being deprecated
- New 'eventfs' subsystem
  - Improves memory efficiency of the tracing subsystem
    - Only allocates inodes and dentries for tracepoints when they are needed
- Shadow Stacks (on Intel, for now)
  - See next page

# Shadow Stacks

- Provides an alternate stack for return addresses (only)
  - Return address is put on regular stack AND on shadow stack
  - Often managed by hardware, for speed (and security)
  - On return, shadow stack is used to detect if the return address on the regular stack has been altered
    - VERY useful for detecting return-oriented programming (ROP) attacks, which are a major source of security threats
- x86 support landed in 6.6
- Patches for 64-bit ARM and RISC-V are in development
  - See <https://lwn.net/Articles/940403/>
- Work on shadow stack support in MUSL C library has started



# Linux v6.7 (January 2024)

- Can enable or disable 32-bit emulation on x86-64 kernels on the kernel command line
  - Can reduce attack surface
- ia64 (Itanium) architecture removed
- More efficient kernel samepage merging
  - See <https://docs.kernel.org/admin-guide/mm/ksm.html>
- Printk now supports per-console locking
  - Allows high-priority message output to take over console from lower-priority message
  - <https://lwn.net/Articles/909980/>

# Linux v6.8 (March 2024)

- 'deadline servers' added
  - Prevents realtime tasks from completely starving normal tasks
- The first real RUST driver was added to the kernel
  - A reference driver for Asix PHYs
- Networking core data structures were refactored for better cache efficiency
  - Improving TCP performance in some situations up to 40%
- The SLAB memory allocator was removed (!!)
  - SLUB is the last one remaining in the kernel
- perf data-type profiling was added

# deadline servers (for less deadly RT)

- Provides a way to prevent realtime tasks from starving normal tasks
  - Allows an admin to fix a "runaway realtime task" problem
  - Replaces realtime throttling feature
- Added in Linux v6.8
- How it works:
  - Deadline scheduling priority is higher than RT priority
  - A deadline server is set up to be started when possible normal task starvation is detected
  - The deadline server runs normal tasks, within it's guaranteed scheduling quanta (e.g. 5%)
- See <https://lwn.net/Articles/934415/>

# perf data-type profiling

- Adds a new sub-command to perf
  - perf annotate --data-type
  - perf annotate --data-type={field-name}
- Can get sample data per-field in a data structure
- Shows offset of structure fields and frequency of access
- Is very useful to see if shuffling the fields in a data structure might (or did) improve cache performance
  - Can check if a frequently accessed field is in a different cache line
  - Or if all frequently accessed fields are in the same cache line
- See <https://lwn.net/Articles/955709/>



# Linux v6.9 (May 2024)

- ext2 file system marked as deprecated
  - Still handled by the ext4 module
- Faster timer setup
  - Don't select the CPU at timer creation
    - (Most timers never expire)
  - See <https://lwn.net/Articles/913568/>
- Work on reducing network stack contention
- The kernel energy model can be updated at runtime
- Mitigation for “Register File Sampling” vulnerability on Intel Atom

# Linux v6.10 (expected July 2024)

- Continued improvements in Rust support
- Encrypted interaction with TPM
  - See Documentation/security/tpm/tpm-security.rst
- crypto stats removed
  - Apparently no one was using them
  - It imposed runtime (and maintenance) overhead
  - <https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=29ce50e078b8>
- Removal of early Alpha CPUs (EV5 and earlier)
  - comment on next page

# Removal of Alpha CPUs

- Early Alpha CPUs did not provide byte-level memory access
- Was the first non-x86 architecture that Linux was ported to
- Linus said:
  - "So while it's a bit sad to see the support for my first alpha go away, if you want to run museum hardware, maybe you should use museum kernels."
- While it's a bit troubling, it's understandable

# Linux v6.10 (expected July 2024) (cont.)

- Memory-allocation profiling
  - tracks all memory allocations in kernel, and what code did the allocation
    - Very useful for debugging memory usage
  - Relies on code\_tagging, which was also added to 6.10
  - Now that it's upstream, work will proceed to tune the overhead of the profiling to make it as unobtrusive as possible
  - See <https://lwn.net/Articles/974380/>
  - Also, see Documentation/mm/allocation-profiling.rst



# Expected in Linux v6.11


- Extensible Scheduler class (sched\_ext)
  - Supports pluggable schedulers, using BPF
  - Linus has said he will merge it in 6.11
    - But there's been a lot of debate, and a request for a 3-month delay
    - See <https://lwn.net/ml/all/87bk3wpnzv.ffs@tglx/>
- See <https://lwn.net/Articles/978007/> and <https://lwn.net/Articles/922405/>

# Long Term Supported Kernels


- 6.6 is the latest long-term support (LTS) kernel
  - Current LTS kernels are: 4.14, 4.19, 5.4, 5.10, 5.15, 6.1, and now 6.6
- Plan is to pick one per year, and only maintain for 2 years
  - Reduction from 6 years upstream support
- Activity (outside of upstream):
  - Linaro working on new LTS support option
  - Japan LTS study group has had meetings
    - See <https://lists.celinuxforum.org/g/Celinux-dev/message/1309>

# Kernel releases (as of June 2024)

## The Linux Kernel Archives

[About](#) [Contact us](#) [FAQ](#) [Releases](#) [Signatures](#) [Site news](#)

Protocol	Location
HTTP	<a href="https://www.kernel.org/pub/">https://www.kernel.org/pub/</a>
GIT	<a href="https://git.kernel.org/">https://git.kernel.org/</a>
RSYNC	<a href="rsync://rsync.kernel.org/pub/">rsync://rsync.kernel.org/pub/</a>

Latest Release  
**6.9.7** 

mainline:	<b>6.10-rc5</b>	2024-06-23	<a href="#">[tarball]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a>	
stable:	<b>6.9.7</b>	2024-06-27	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
stable:	<b>6.8.12 [EOL]</b>	2024-05-30	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>6.6.36</b>	2024-06-27	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>6.1.96</b>	2024-06-27	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>5.15.161</b>	2024-06-16	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>5.10.220</b>	2024-06-21	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>5.4.278</b>	2024-06-16	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>4.19.316</b>	2024-06-16	<a href="#">[tarball]</a>	<a href="#">[pgp]</a>	<a href="#">[patch]</a>	<a href="#">[inc. patch]</a>	<a href="#">[view diff]</a>	<a href="#">[browse]</a> <a href="#">[changelog]</a>
linux-next:	<b>next-20240627</b>	2024-06-27						<a href="#">[browse]</a>

# Contributions by embedded Linux companies (to kernel)

Company	Commits since June 2023	Top contributor	Work area(s) (of top contributor)
Baylibre	254	David Lechner	AD2S1210 driver, spi stuff
Bootlin	489	Miguel Raynal	mtd rawnand, nvmmem, mac802154 driver
Collabora	694	AngeloGioacchino Del Regno	mediatek processor support, panfrost GPU
Ideas On Board	369	Laurent Pinchart	12c, camera, media drivers
Igalia	115	Maíra Canal, Melissa Wen	drm GPU driver
Linaro	4155	Krzysztof Kozlowski	sound, device tree, Samsung clocks
Linutronix	563	Thomas Gleixner	timers, printk, x86, preempt_rt
Pengutronix	1939	Uwe Kleine-König	driver cleanups (remove callback returning void)
Toradex	82	Francesco Dolcini	drm bridge fixes
Wind River	71	Ovidiu Panait	sahara crypto driver



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# Event Slides and videos resources

- I'm going to refer to sessions from Embedded Linux Conference 2024 (ELC) (from April)
  - Use [https://elinux.org/ELC 2024 Presentations](https://elinux.org/ELC_2024_Presentations) to find the slides and video links
    - Search by title and/or presenter name

# Boot time

- Talks from ELC2024
  - "Unlocking the Potential of Suspend to RAM using Linux in a Multi-Core Multi-Firmware Automotive SoC"
    - Gregory Clement, Bootlin
    - Explores issues with Suspend-to-RAM (S2R)
      - Tradeoffs in boot speed and power usage while suspended
    - Multiple-cores means lot of handoffs and security concerns
  - "Deferred Memblocks Init for Boot Time Reduction"
    - Suarshan Rajagopala, Qualcomm
    - Initialize part of memory first, then rest of memory later

# Boot time

- Talks from ELC2024
  - "Software Optimization for Early Linux Boot for Time Critical Applications"
    - Aashvij Shenai & Soumya Tripathy, Texas Instruments
    - Optimized loading of kernel image from bootloader
    - Also analyzed kernel config and filesystems optimizations for boot time reductions



# Core kernel

- A generic ring buffer for the kernel
  - A proposal for a unified ring buffer mechanism in the kernel
    - This has been proposed many times, and many already exist
  - Maybe this one will make progress and replace other implementations
  - See <https://lwn.net/Articles/976836/>
    - See also <https://xkcd.com/927/>

# Graphics – GPU work

- Mesa 24.1 released in May
  - Support for Panfrost, Zink, NVK announced by Collabora
  - See <https://www.collabora.com/news-and-blog/news-and-events/mesa-241-brings-new-hardware-support-for-arm-and-nvidia-gpus.html>

# Graphics – GPU work

- "Raspberry Pi 5: Challenges and Solutions in Bringing up an OpenGL/Vulkan Driver for a new GPU"
  - by Alejandro Pineiro Iglesias, Igalia
  - Good overview of Raspberry Pi upstream driver work
  - Rpi 5 required substantial rework
    - Worked was done with a simulator, before hardware became available
    - Vulkan 1.2 and OpenGL ES 3.0 conformant

# Graphics – Frameworks - Flutter

- Flutter Status
  - Still going strong
    - Announced to be on all future LG TVs (on WebOS)
    - However, Google did lay off the Flutter dev team
  - But there was still a status update at Google I/O, 2 weeks later (!?)
  - <https://medium.com/flutter/all-the-flutter-news-from-a-busy-google-i-o-2024-7c963c064f8d>
- One focus on ability to develop casual games
  - Ability to play raycasting game using flutter
    - See <https://github.com/atamocius/flutterstein-3d>



# Filesystems and I/O

- Block IO speedup (added in v6.9)
  - Cache time to avoid lookup overhead during issue-side of IO ops
  - Yields about 6% performance improvement
  - See <https://www.phoronix.com/news/Linux-Caching-Time-Block-IO>
- Talk "Maximizing SD Card Life, Performance, and Monitoring with KrillKounter"
  - By Andrew Murray, The Good Penguin
  - Great overview of SDCard / NAND flash hardware and software issues
    - Write amplification, how to measure it and avoid it
    - Need to measure at block layer and optimize
    - <https://github.com/The-Good-Penguin/tgp-krill-kounter>

# Networking



- "In the kernel Trenches: Mastering Ethernet Drivers on Linux"
  - By Maxime Chevallier, Bootlin
  - Excellent overview of structures and issues for a kernel driver
- "Bluetooth on Embedded Linux Systems Deep Dive"
  - by Marcel Ziswiler, Toradex
  - Good overview of Bluetooth development issues
    - Overview of hardware, Linux driver code, debugging techniques, etc.

# Realtime - PREEMPT\_RT - What's left

- What's left in PREEMPT\_RT patches out of mainline:
  - this year (2024) (patches-6.9-rt5):
    - about 2900 lines of code, affecting 79 files (in 101 patches)
    - 46 printk patches, 9 DRM
    - A few patches each for ARM, PowerPC, Risc-V
    - **tty/serial patches appear to be upstream!!**
  - Thomas says that printk changes are the blocker to allow enabling PREEMPT\_RT in the mainline kernel
- See <https://mirrors.edge.kernel.org/pub/Linux/kernel/projects/rt/6.9/>
- I still think this is a bad way to get RT (try Xenomai instead)

# Security



- Security Talks:
  - "Patterns and Anti-Patterns in Embedded Development: What Security Incidents of 2023 Teach Us"
    - By Marta Rybczynska, SyslinBit
    - Trains geo-locked by the supplier to prevent 3<sup>rd</sup> party maintenance
    - HTTP/2 DoS attacks
    - Signing keys exposed during a ransomware attack
    - Xz utils backdoor
    - See <https://lwn.net/Articles/970818/>



# Security talks (cont.)

- Security Talks:
  - "Standardizing the Generation and Signing of Boot Images"
    - By Neha Francis & Vignesh Raghavendra, Texas Instruments
    - Issues with Signing boot images, when bootloader architecture is complex
    - Introduce "binman" tool – for signed binary image management
      - Show how they modified it for TI boot architecture

# Security talks (cont.)

- "Engineering Secure SSH Access for Engineers"
  - by Colin McAllister, Garmin
  - Issues with leaving ssh enabled on a product
    - Best security is to remove sshd, but then remote support is hard
  - Recommendation to use "Certificate" authentication
    - Versus password, public key, or PAM authentication
  - Describes how to set it up

# Kernel community – CVE handling

- Linux kernel community becomes a CNA
  - CVE assignment is fraught with issues
    - Sometimes the project members disagrees with the impact and severity assessments of the security researcher
    - CNA (Certified Number Authorities) control CVE assignment for their project
  - See <http://www.kroah.com/log/blog/2024/02/13/linux-is-a-cna/>
  - Policy summary: assigning CVEs only to fixed issues; invalidating non-vendor specific CVEs released by other CNAs
- Other projects that recently became CNAs: glibc, curl, python

# Linux CNA – status report

- There have been some complaints that the kernel CNA team produces too many CVEs
  - Produces many more than old process (which was ad hoc)
  - Is NOT true that there's a CVE for every patch
- Some argue that not enough CVE filtering is done
  - Distro vendors who are managing CVEs are swamped
  - Filtering CVEs is difficult, due to openness of kernel
  - Who should bear cost of security analysis (upstream?, OS vendors?)
- See <https://lwn.net/Articles/978711/>



# System Size

- SLAB memory allocator removed from kernel (v6.8..)
  - SLOB was removed in 6.4
- Only SLUB remains
  - Use CONFIG\_SLUB\_TINY for small systems
- A 15-cent processor can run Linux
  - CH32V003 RISC-V processor (running a RISC-V emulator)
  - 48 MHZ processor
  - With 8MB SPI NOR chip, and an SD card
  - See <https://blog.adafruit.com/2024/02/19/linux-on-a-0-15-ch32v003-risc-v-microcontroller-riscv-linux/>

# Testing (talks)

- "Testing Rotation Sensor Drivers with LEGO Robots and Other Adventures in the Linux IIO Subsystem"
  - By David Lechner, Baylibre
  - Linux driver testing using physical hardware
  - Used legos to physically rotate, and compared sensor results to detect driver bugs
- "Enveiling the Test Champions: Comparing Test Automations Systems for Embedded Environments"
  - by Pawl Wieczorek, Collabora
  - Compared LAVA, labgrid, boardswarm, beaker

# Toolchains - GCC

- GCC 14.1 released May 7, 2024
  - New '--fhardened' flag to enable security-hardening features
  - Vectorizer improvements
  - More improvements in the static analyzer
    - See <https://lwn.net/Articles/946733/>
      - And <https://developers.redhat.com/articles/2024/04/03/improvements-static-analysis-gcc-14-compiler>

# Toolchains - LLVM

- LLVM 18.1.0 released March 5, 2024
  - See <https://releases.llvm.org/18.1.0/docs/ReleaseNotes.html>
  - Support for multiple new RISC-V extensions, new ARM processors
  - Better support of C++23 and C23
  - Note: This is the first 18.x release (no 18.0) - this represents a change of versioning scheme
- People are using LLVM for whole distributions, not just the kernel



# Toolchain resources

- Presentation: "Toolchain Options in 2023: What's New in Compilers and Libcs"
  - at ELC 2023, by Bernard Rosenkranzer, BayLibre
- Still can use traditional toolchain elements, but there are interesting alternatives:
  - binutils: ld, lld (LLVM), mold linker
    - Mold linker is intended to be much faster (and it is)
    - Support LTO for both gcc and LLVM
  - Compilers: gcc, clang (LLVM), TinyCC
    - Similar performance, some BSPs only on gcc or clang
- See [https://elinux.org/images/8/84/EOSS23 - Toolchain Options in 2023 - What%27s New in Compilers and Libcs.pdf](https://elinux.org/images/8/84/EOSS23_-_Toolchain_Options_in_2023_-_What%27s_New_in_Compilers_and_Libcs.pdf) and <https://youtu.be/Vgm3GJ2ItDA>

# Toolchain downloads

- Popular embedded configurations available in mainstream distributions
- A wide choice of architectures at <https://toolchains.bootlin.com/> (including bfin,nios2, openrisc...)
- GCC-based with options for glibc/musl/uclibc

# Tracing

- BPF tracing performance
  - Developers are working on refactoring how dynamic probes (uprobes) are inserted (which instructions to overwrite, and how calls work, etc.)
    - Can result in 250% tracing performance speedup
    - But some techniques are Intel-only
  - See <https://lwn.net/Articles/978335/>
- BPF capturing stack traces asynchronously
  - See <https://lwn.net/Articles/978736/>

# Tracing

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# Tracing

- tracefs user-space accessible ring buffers
  - Can mmap ftrace buffers in users space
  - For less data copies
  - See <https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=a1e0dd7ce38a>
- Kexec: Allow preservation of ftrace buffers
  - Allow ftrace buffers to persist over a Kexec HandOver (KHO)
    - ftrace is actually just a proof of concept (and a handy one) for full pre-kexec state preservation for a new running Linux instance
  - See <https://lwn.net/Articles/958505/>

# Build Tools and Distros

- Yocto Project
  - Latest = 5.0 (Scarthgap), released April, 2024
    - Is an LTS (Long Term Support) release
    - Support for genericarm64 (SystemReady systems)
    - Default kernel 6.6 (LTS), hundreds of packages updated
    - new 'bmaptool' for more efficient image flashing
      - See <https://github.com/yoctoproject/bmaptool>
  - See <https://docs.yoctoproject.org/next/migration-guides/release-notes-5.0.html>

# Miscellaneous – Raspberry Pi news

- Raspberry Pi Connect
  - Supports web-based remote GUI support
    - It uses VNC running over WebRTC
  - Also supports remote shell
    - Secure, web-based shell access
  - See <https://www.raspberrypi.com/news/raspberry-pi-connect/>
  - See <https://www.raspberrypi.com/news/raspberry-pi-connect-remote-shell-access-and-support-for-older-devices/>

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# Industry News

- Cyber Resilience Act (CRA)
- Update on SFC vs. Vizio
- HDMI Forum preventing creation of open source HDMI driver
- Linux on Mars

# CRA (Cyber Resilience Act)

- Mandatory cyber security framework for software and hardware (including embedded!) in the EU
  - Security updates becoming mandatory (by default 5 years)
  - Due diligence of all components of products (including OSS)
  - Documentation requirements
  - Mostly self-assessment, 3rd party assessment for some categories of products
- Extends the CE marking
- Expected final publication around October 2024
  - Then full application in 2027
  - Details (standards) to be specified during 2024-2027 period

# Update on SFC vs. Vizio

- Is important, because SFC is asserting a novel interpretation of GPL rights
  - 3<sup>rd</sup> party beneficiary rights
    - which would allow any 3<sup>rd</sup> party to enforce the license
  - that GPL is a contract, not a license
- Latest update:
  - Vizio and SFC both deposed the Linux Foundation
  - Trial in late July, 2024, in Santa Ana California
  - Many lawyers are watching this one
- Random note: Walmart is trying to acquire Vizio

# HDMI 2.1 can't have an open source driver

- HDMI Forum told AMD that it can't make an open source driver for HDMI 2.1
  - Means that Linux users can't use highest resolution and frame rates
  - Is a big problem for GPU drivers (which often include audio driver technology for HDMI support)
- Public access to spec has been a problem since at least 2021
  - See <https://www.phoronix.com/news/HDMI-Closed-Spec-Hurts-Open>
- See <https://arstechnica.com/gadgets/2024/02/hdmi-forum-to-amd-no-you-cant-make-an-open-source-hdmi-2-1-driver/>



# Linux on Mars



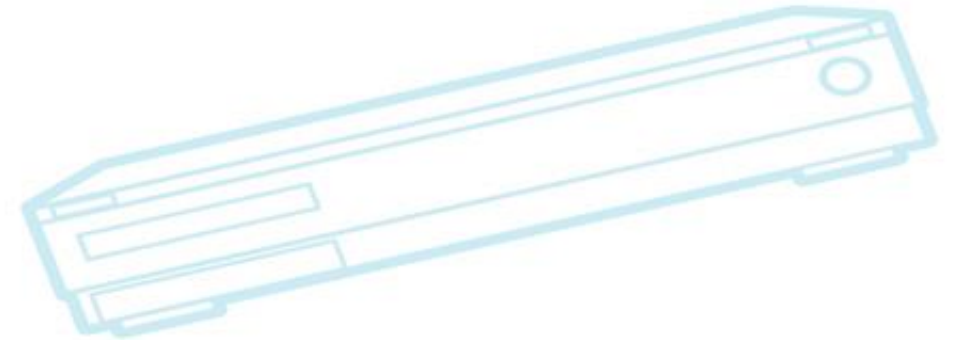
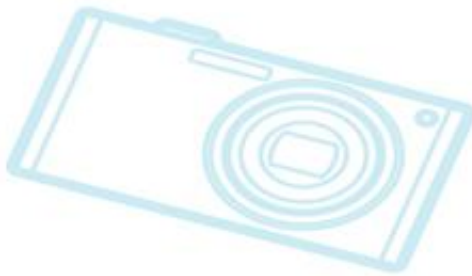
- Broken helicopter continues to collect data
  - It wakes up every day (temperature data and some pictures)
  - Rover is not close enough to receive it via radio
    - But if it ever circles back, it could collect it later
  - Can store several years of data on its flash drive
- Proposal to use Linux on the wireless base station on the rover for something
  - Processor is faster than rest of CPUS on the rover combined
  - Proposal to use for location processing (improved accuracy)

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# Community

- Conferences
- Elinux wiki



# Conferences

- Embedded Linux Conference
  - Last one: April 16-18, 2024 in Seattle, USA, part of EOSS
    - See <https://eoss24.sched.com/>
    - And [https://elinux.org/ELC\\_2024\\_Presentations](https://elinux.org/ELC_2024_Presentations)
  - Conference topics (not already covered):
    - Audio (pipewire), Audio PM, V4L2, clocks and PM, Apertis, Rust, DTS validation, update, machine vision for drones, deferred work in the kernel, Yocto, Update systems, Webkit, display sharing, libcamera, Virtio for AMP systems, RISC-V, upstreaming, debugging with OpenOCD, and many more.
  - Don't miss my keynote (and closing game) either!
    - Lessons from embedded Linux in Space (but it was not named that)



# Conferences (coming soon)

- Embedded Linux Conference Europe 2024
  - Sept. 16-17, 2024 in Vienna, Austria
    - ELC Europe (Vienna) will be a smaller event this year
      - 2 days, 2 tracks
- Embedded micro-conference at Linux Plumbers
  - Also in Vienna, Sept. 18-20, 2024

# Conferences (coming soon, cont.)

- Open Source Summit Europe
  - Sept. 16-18, 2024 in Vienna, Austria
  - Lots of sub-conference and co-located events
- Linux Plumbers
  - Sept. 18-20, 2024 in Vienna Austria
  - Embedded and IOT micro-conference (see next page)
- Open Source Summit Japan
  - Oct. 28-29, Tokyo, Japan

# Embedded and IOT micro-conference



- Part of Linux Plumbers, in Vienna
  - Sept. 18 or 20 in Vienna
- CFP for micro-conference topics is still open
  - Focus this year is on boot-time
    - Instrumentation, testing, technology
    - Time-critical boot phase, vs. ordinary
    - Pre-initialized hardware
    - Techniques: Parallel init, cached probing, etc.
  - Deadline = July 5 (for this micro-conference)
  - See <https://lpc.events/event/18/abstracts/> to submit topic proposal

# Elinux wiki

- Linux Foundation hired Bill Traynor as a fulltime employee
  - Will do elinux administration as part of his job
- Site is still used for:
  - Materials for embedded Linux development boards
  - Some academics use it for coursework
  - Event materials: slides and links to videos for ELC
- Some areas of the site are out-of-date
- The site is underutilized for sharing information
- Looking for volunteers to help with the site
- Have set up an LFX Crowdfunding site
  - <https://crowdfunding.lfx.linuxfoundation.org/initiative/5fa1a40a-d4f0-4576-81c6-57319a591a87>
  - Have \$10,000 that can be spent to improve site or generate content



# Outline

Linux Kernel  
Technology Areas  
Industry News  
Community  
**Conclusions**

# Conclusions

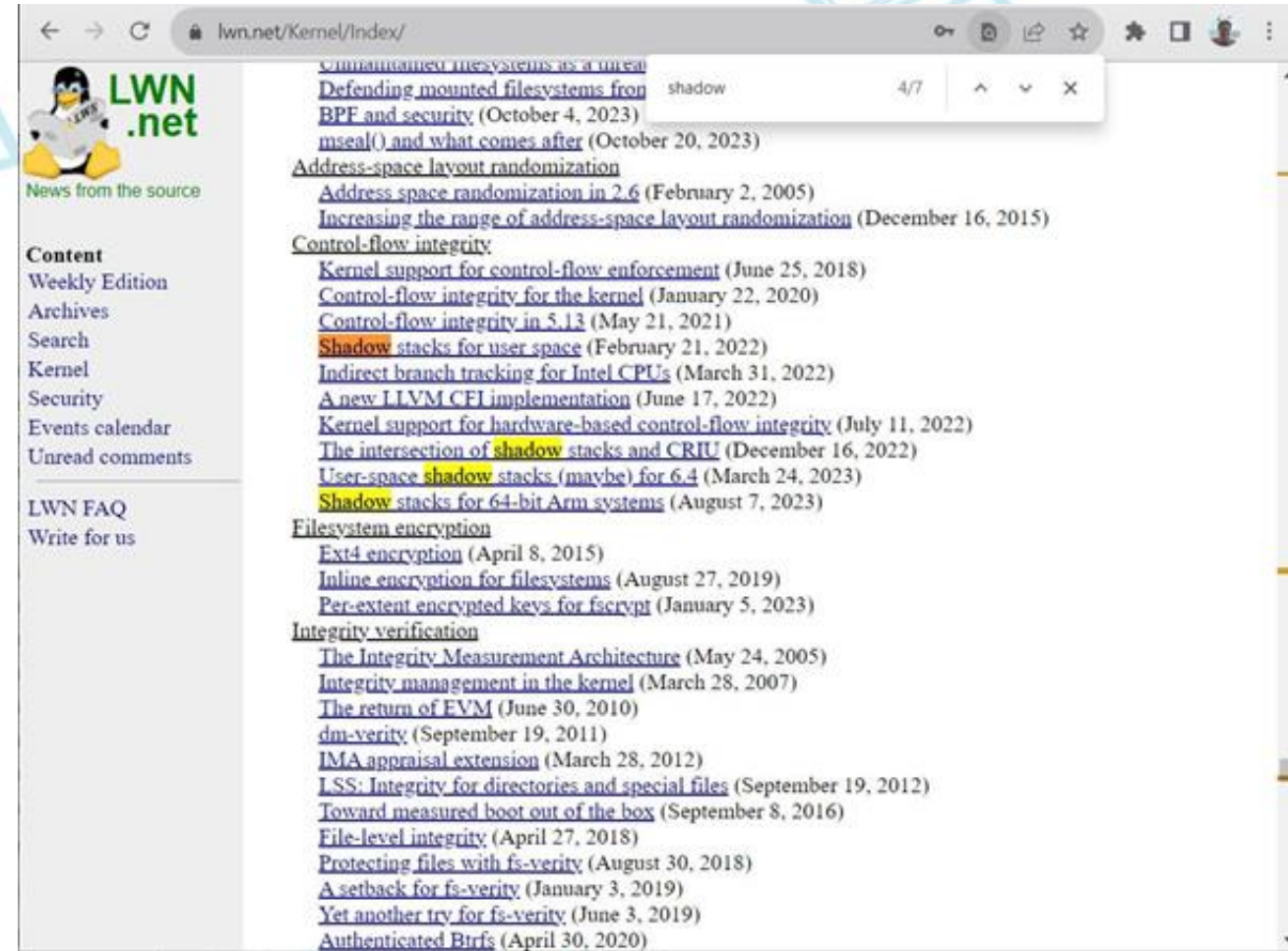
- Overall – we're doing very well
  - Embedded Linux is widely deployed and functional (billions of devices)
- Core kernel systems are in place to support embedded
  - But new hardware keeps being made
  - We'll always have things to write and upstream
- More investment is needed by the users of Embedded Linux in the infrastructure and community ecosystem
- What do you think is missing to support embedded development?

# Resources

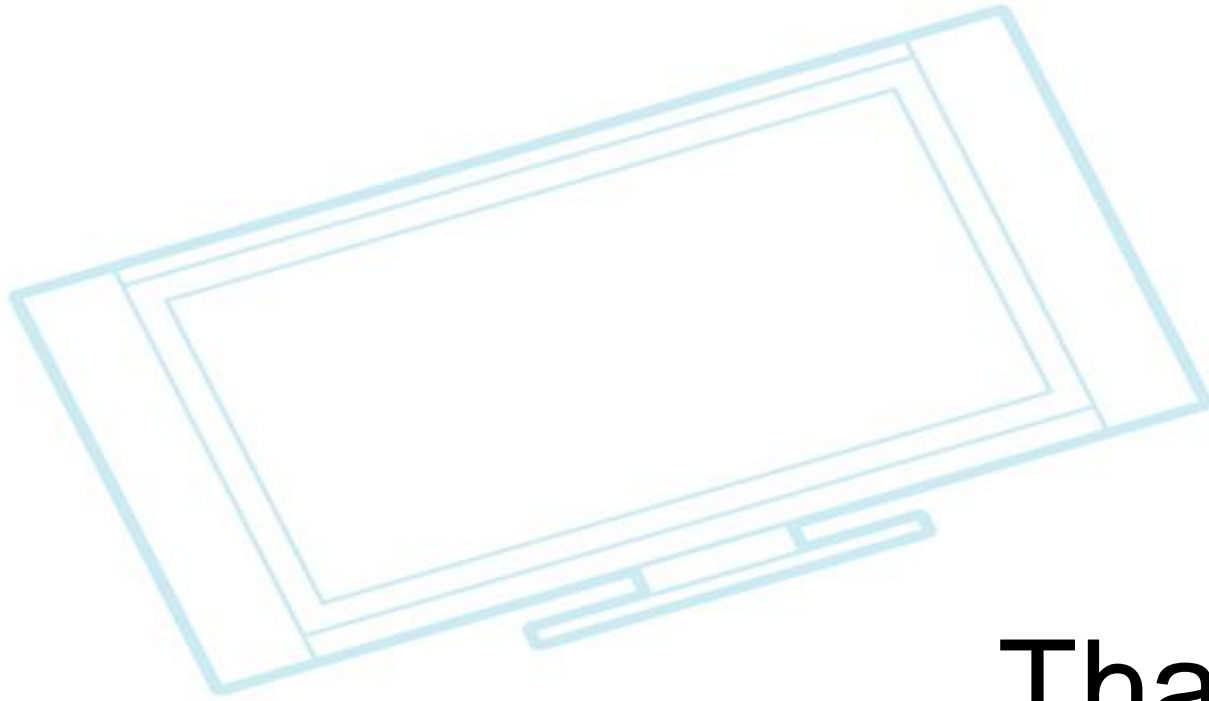
- Lwn.net
  - <https://lwn.net>
- Phoronix
  - <https://phoronix.com>
- Kernel Newbies
  - e.g. [https://kernelnewbies.org/Linux\\_6.9](https://kernelnewbies.org/Linux_6.9)
- Elinux wiki:
  - <https://elinux.org>
  - Especially the event pages: [https://elinux.org/ELC\\_Presentations](https://elinux.org/ELC_Presentations)
- Linux Foundation Newsletters
- Kernel Mailing lists
- Google
- Check: <https://embeddedlinuxconference.com/> for event info

# LWN.net Resource for Kernel Information

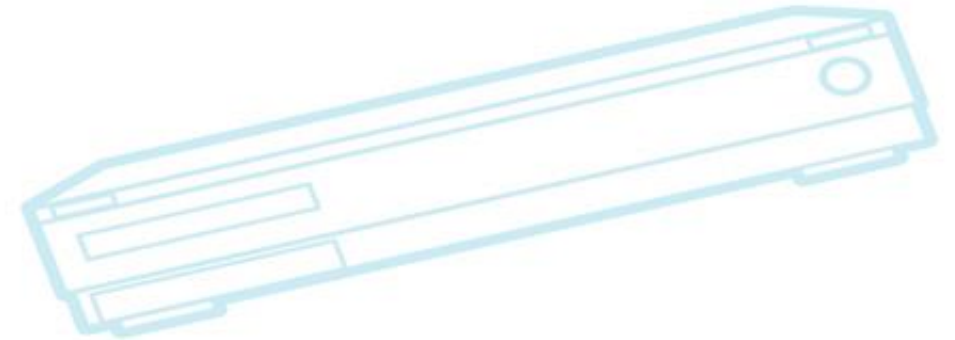
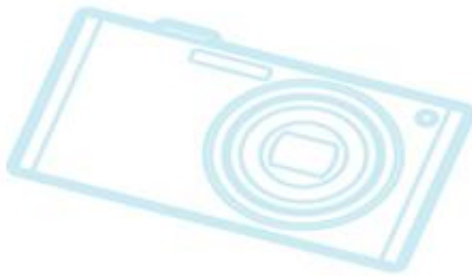
- LWN.net Kernel Index
  - Has many years of articles
  - Sorted by kernel subsystem and topic
- <https://lwn.net/Kernel/Index/>







Thanks!





# Extra Information

# Issues From Embedded Linux Leadership Summit 2023

- Security is an ongoing concern
- OTA updates
- Long-term support
- Heterogeneous core support
- Shared testing
- Safety critical / certification
- Standardization of HW components
- AOSP competition
- Lack of investment in infrastructure/ tools/ upstreaming
  - (not enough contributions)
- RT marketing
- Upstream AI/ML accelerators
  - Support for AI processing units (APU)

# Linux Foundation projects

- Linux Foundation
  - Automotive Grade Linux (AGL) – handles automotive vertical
  - Civil Infrastructure Platform (CIP) – handles support longevity
  - Core Embedded Linux Project – is shutting down
  - DroneCode – handles drone vertical
  - ELISA – handled issues with safety certification and standards
  - KernelCI – handles automated testing (for upstream)
  - OpenChain – handles issues with entities in the supply chain
  - OpenSSF – working on security throughout OSS ecosystem
  - Yocto Project – build system for embedded OSS (not just Linux)



# Automotive Grade Linux (AGL)

- Latest release = Prickly Pike (16.0)
  - Continued evolution of the Flutter support (by Toyota)
    - Flutter reference apps
    - Flutter workspace automation
  - Chromium Embedded Framework (CEF) available as a build option
  - Instrument cluster container improvements and demo
  - Systemd unit based application activation (tech. preview)
- Based on Yocto 4.0 (kirkstone) release
- Rust meta-layer for Yocto Project
  - Enables the latest Rust version to be used with AGL
  - It was upstreamed to Yocto Project as well
- Check out Walt Miner's talk last week at OSSJ for more info

# Civil Infrastructure Platform

- Added 6.1-cip kernel version for super-long-term support
  - All CIP kernels are supported for at least 10 years
- Worked on the IEC 62443 security standard
  - International series of standards for cybersecurity in automation and control systems

# DroneCode

- Manages several OSS projects in the drone ecosystem
  - PX4 – open source autopilot software
  - QGroundControl – ground control station software
  - MAVLink – lightweight messaging protocol
  - Pixhawk – open hardware standard for flight management units

# ELISA

- ELISA = Enabling Linux in Safety Applications
- New 2023 seminar series about various safety-related topics
- Aerospace Workgroup
  - Working to identify challenges to adopting Linux in aerospace
- Medical Workgroup
  - Published methodology to trace specific workloads to identify kernel subsystem dependencies (for medical applications)
- Published ks-nav tool
  - Perform analysis of Linux kernel according to System-Theoretic Process Analysis (STPA) methods
    - See <https://elisa.tech/blog/2023/06/05/diving-into-the-kernel-introducing-ks-nav-tool-set/>
- Created a reference system with Linux, Xen and Zeph
  - Worked on CI tools



# OpenChain

- OpenChain – helps with supply-chain issues
- Standards:
  - Open source license compliance standard ISO/IEC 5230
  - Security assurance program
- Finalized ISO/IEC 18974 standard for security assurance
  - Helps organizations define processes to check OSS for known security vulnerability issues (like CVEs, GitHub alerts or package manager alerts)
  - Identifies security process, roles and responsibilities, etc.
  - Should be published as a formal ISO standard by now (or soon)